Fisheries and Oceans Canada / Pêches et Océans Canada
Science / Sciences

**Canadian Science Advisory Secretariat (CSAS)**

**Research Document 2014/031**

**Gulf Region**

# Environmental conditions in the southern Gulf of St. Lawrence relevant to lobster

J. Chassé[1], N. Lambert[2], M. Comeau[1], P.S. Galbraith[2], P. Larouche[2], and R.G. Pettipas[3]

[1]Fisheries and Oceans Canada, Gulf Region
Gulf Fisheries Centre
P.O. Box 5030, 343 Université Avenue
Moncton N.B. E1C 9B6

[2]Fisheries and Oceans Canada, Quebec Region
Ocean Science and Environment Directorate, Maurice Lamontagne Institute
P.O. Box 1000, 850 Route de la Mer
Mont-Joli QC G5H 3Z4

[3]Fisheries and Oceans Canada, Maritimes Region
Ocean Sciences Division, Bedford Institute of Oceanography
P.O. Box 1006, 1 Challenger Drive
Dartmouth NS B2Y 4A2

September 2014

Canada

## Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

**Published by:**

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca


ISSN 1919-5044

**Correct citation for this publication:**

Chassé, J., Lambert, N., Comeau, M., Galbraith, P.S., Larouche, P., and Pettipas, R.G. 2014. Environmental conditions in the southern Gulf of St. Lawrence relevant to lobster. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/031. v + 25 p.

## TABLE OF CONTENTS

## ABSTRACT

Environmental conditions in the southern Gulf of St. Lawrence (sGSL) were examined in relation to lobster (*Homarus americanus*). Data analysis show that recent annual mean air temperatures over the sGSL have been above normal, with 2010 having the highest temperature on record surpassing 1999, 2006 and 2012. Furthermore, maximum ice volumes of years 2010 to 2012 were among the lowest values since 1969. This is in agreement with the volume of the Cold Intermediate Layer that shows a decrease in recent years. Sea Surface Temperature, based on satellite imaging, has been generally increasing between 1986 and 1999, and relatively stable since in each Lobster Fishing Area (LFA). The ocean surface degree-days accumulation over 4°C was variable but for all LFAs, the rate was the fastest in 2006 and the slowest in 2011. Small increases in bottom water temperatures were observed since the mid 1990's in several LFAs. Frequency distribution calculations show that 95% of the lobsters were found in bottom water temperatures between 0.1 and 13.3°C in June while they were found in temperatures between 2.5 and 18.2 °C in September. Based on bottom water temperatures, the habitat index of lobster shows significant variability and it has been increasing in June during the 1999-2012 time period. In September, an increase of the habitat index of lobster is also observed during the same period but to a lesser extent.


**Conditions environnementales dans le sud du golfe du Saint-Laurent relativement au homard**


## RÉSUMÉ

Les conditions environnementales dans le sud du Golfe du Saint-Laurent (sGSL) ont été examinées relativement au homard (*Homarus americanus*). L'analyse montre que les récentes températures annuelles moyennes de l'air au-dessus du sGSL ont été au-dessus de la normale avec la plus haute valeur enregistrée en 2010, surpassant les valeurs de 1999, 2006 et 2012. De plus, les volumes maximum de glace de mer de 2010 à 2012 étaient parmi les plus faibles depuis 1969. Ceci est en accord avec le volume de la Couche Intermédiaire Froide qui montre une diminution au cours des dernières années. Les températures de la surface de l'océan, basées sur la télédétection, ont généralement augmentées entre 1986 et 1999 et sont demeurées relativement stable par la suite dans les Aires de Pêches du Homard (APH). L'accumulation de la chaleur au-delà 4°C par la surface de la mer pour toutes les APHs était variable avec le taux le plus rapide observé en 2006 et le taux le plus lent en 2011. De petites augmentations de la température de l'eau près du fond ont été observées depuis le milieu des années 1990 dans plusieurs APHs. Une analyse en fréquence de distribution montre que 95% des homards ont été trouvés dans des eaux de fonds ayant une température entre 0,1 et 13,3°C en juin et 2,5 à 18,2°C en septembre. L'indice d'habitat du homard, basé sur la température des eaux de fond, montre une variabilité significative et la valeur pour le mois de juin a augmentée de 1999 à 2012. Quoique plus faible, une augmentation est aussi observée pour l'indice de septembre durant la même période.

## INTRODUCTION

Lobster (*Homarus americanus*) is a eurythermal species found in water temperatures ranging from -1 to 26°C (preferred temperatures: 4 to 18°C), and typically inhabiting bottom depths of 2-50 m (Lawton and Lavalli 1995). The lobster fishery is presently the most important resource in eastern Canada with total landings of 71,528 t in 2012 and it is valued at over $664 million, including an active and lucrative fishery in the southern Gulf of St. Lawrence (sGSL) (Figures 1 and 2). The most recent regional peer review meeting for the stock status, fishing effort, biological and the environment characteristics of the lobster fisheries in the sGSL took place in February 2013 (DFO 2013). The purpose of this research document is to provide information on air temperature, ice, sea temperature and salinity between 1981 and 2012 in the sGSL, including lobster fishing areas (LFAs) 23, 24, 25, 26A and 26B. These LFAs were further divided in 9 sub-regions (LFA 23BC, 23G, 24, 25N, 25S, 26AD, 26APEI, 26ANS and 26B) (Figure 3) to better reflect the lobster biological properties, in terms of management areas, as proposed by Comeau et al. (2008). The distribution of lobster as a function of temperature is presented and a habitat index is developed for June and September.

## DATA

Air temperature records were available for the Magdalen Islands, Quebec (Qc), Charlottetown, Prince Edward Island (PEI) and Miramichi, New Brunswick (NB). Recent data from these sites were obtained from the Environment Canada website and pre-1980 data from the climate indices database at the Bedford Institute of Oceanography (BIO).

Sea-ice data covering the sGSL were obtained from the Canadian Ice Service (CIS). Daily charts were examined to determine the position of the ice edge (10% concentration) at specified dates through the winter. Digital versions of the weekly ice charts from CIS were used to update the gridded sea-ice databases at BIO and Institut Maurice-Lamontagne (IML) (Drinkwater et al. 1999; Galbraith et al. 2013). These databases contain the concentrations by ice type and the area covered in the Gulf of St. Lawrence (GSL) for the years 1963 to present. Standard average thicknesses were attributed to each ice category to estimate the ice volume. From this data, we obtained estimates of the date of first presence of sea ice, last presence and duration of ice for each year and we derived a 1971-2000 climatology.

The Sea Surface Temperature (SST) data were provided by IML remote sensing laboratory. The SST data is generated using National Oceanic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer (AVHRR) satellite images. The images were processed at IML. For the purpose of this study, we retained the mean SST at each grid node calculated by averaging all the satellite passes during one day. Sea water temperature and salinity data in LFAs were available from surveys conducted in the sGSL. For example, a total of 355 stations were sampled during the snow crab survey conducted from July to September 2010. The DFO's annual multi-species survey (formerly the groundfish survey) was carried out in September and 145 stations were sampled in 2010. The snow crab survey obtained near-bottom temperatures with a thermistor recorder attached to the trawl. Sea water temperature and salinity profiles were typically collected with a conductivity-temperature-depth (CTD) instrument. Other temperature data for the sGSL were obtained from the Integrated Science Data Management (ISDM) in Ottawa, Canada's national oceanographic data archive, and were from additional fisheries surveys, research surveys and measurements from ships-of-opportunity. Bottom water temperatures were also obtained from VEMCO temperature probes deployed close to the bottom in some of the LFAs and these data are archived at Gulf Fisheries Centre (GFC) in Moncton, NB. The lobster concentrations expressed as t per $km^2$ were from a database maintained by the lobster research group at the Gulf Fisheries Centre, Moncton, NB.

## METHODS

Historical sea water temperature and salinity data from CTD profiles were interpolated to ~500 m and ~2 km resolution grids of the GSL. A weighted nearest neighbour interpolation approach was used to grid the data for June and September from 1971 to 2010 on the 2 km grid and an objective analysis method used for interpolation on the 500 m grid. Lack of data in some years prevented the estimation of complete temperature and/or salinity fields. This approach allows for the estimation of mean properties of oceanographic fields as well as statistics of variability.

The lobster concentration was calculated per statistical district by using landings reported in the sale slips database, i.e., a database consisting of a compilation of sale transactions conducted between official lobster buyers and harvesters. The frequency distribution of the lobster concentration as a function of bottom water temperature was calculated for each 0.1 °C and the bracketing temperatures were determined based on the 95% distribution leaving 2.5% on each side of the frequency distribution. The temperature habitat index was defined as the area of the bottom covered by the bracketing temperatures (favorable temperature range for lobster) and calculated from the gridded temperature fields derived from the oceanographic surveys. The bottom water temperature at each grid point was assigned to the area of bottom associated with that particular grid cell. The areas with temperatures within the favourable range were then summed. The mean bottom water temperature within this area was estimated. The time series of the indices began in 1971 for the sGSL.

## RESULTS AND DISCUSSION

### AIR TEMPERATURES

The air temperature record at Charlottetown began in 1873.The annual mean air temperatures at Charlottetown were significantly warmer than their long-term average during recent years (Figure 4). The annual mean air temperatures were below the 1981-2010 average in most years prior to 1930. The 1950s show warmer than normal conditions and oscillations of about a 15-year period can be seen until the late 1990s. Recent air temperatures have been above normal, with 2010 being the highest temperature on record surpassing other extreme values recorded at this site in 1999, 2006 and 2012. For the entire GSL, Galbraith et al. (2012) reported a warming trend of 0.9°C per century between 1873 and 2011 in the average April-November air temperature.

### SEA-ICE

The average day of the first and last ice occurrence between 1971 and 2000, and the number of days with ice (ice duration) are presented in Figures 5 to 7. The latter is not the simple difference between the dates of first presence and last presence since the ice may come and go. During a typical year, ice will initially form along the coastal regions of the Magdalen Shallows and spread eastward (Figure 5). By mid-January, ice usually covers half of the Shallows and most of the sGSL is covered by early February. On average, the ice duration varied from 95 days around the mouth of Gaspe Bay to more than 110 days along the north coast of PEI and along Cape Breton. Regional statistics for 1969-2012 are presented in Figure 8 (adapted from Galbraith et al. 2013, who use slightly different methods). In terms of ice volume, years 2006 and 2010-12 showed the lightest ice conditions since 1969.

## VERTICAL TEMPERATURE AND SALINITY STRUCTURE

September average sea water temperature and salinity profiles for the sGSL (Figure 9) show three separate layers: the surface layer, the cold intermediate layer (CIL), and the deeper water layer (see Galbraith et al. 2013 for more details). At typical depths of the sGSL (~70 m), the bottom is covered with the CIL waters and therefore temperatures are usually <1°C over a large portion of the Magdalen shallows. An estimation of the water volume <1°C is shown in Figure 10. It is clearly seen that the greatest quantities of cold water occurred in the 1990s in the sGSL, followed by a return to more normal conditions towards the end of the time series and a significant decrease in 2011-12.

## SEA SURFACE TEMPERATURE (SST)

SST monthly climatology (1986-2012) for May to December is shown in Figure 11 for the sGSL. Maximum temperatures are typically reached in August and minimums during the winter months (-1.5 °C, not shown). The average seasonal cycle (defined as the difference between the minimum winter temperature and the maximum summer temperature) in the sGSL can therefore reach over 25 °C (Figure 12). The highest SST ever recorded at every grid point since 1986 is shown in Figure 13. Figures 14 to 17 show the time series of the average SST in each LFA for June to September; it can be seen that the SSTs have been generally increasing between 1986 and 1999 and relatively stable since then, albeit with some inter-annual variability.

The ocean surface degree-days accumulations over 4°C at the surface between May 1$^{st}$ and September 15$^{th}$ for each LFA between 2006 and 2012 are shown in Figure 18. In recent years, the heat accumulation rate in the ocean surface layer was the fastest in 2006 and the slowest in 2011 over all the LFAs. However, the 1986-2012 time series of degree-days accumulation over 4°C at the surface between May 1st and July 15th (Figure 19) shows that there were other years when heat accumulated quickly in some LFAs at the beginning of the summer (e.g. 1995 and 1999).

## BOTTOM WATER TEMPERATURE

On average, there is a large area of the central Magdalen Shallows covered by bottom water temperatures below 0°C in June (Figure 20). From the centre of the Magdalen Shallows, bottom water temperatures tend to increase towards the shallower, near shore regions and towards the deeper Laurentian Channel. Hence, cold waters throughout the summer in the sGSL are found at intermediate depths ranging from 50 to 150 m, which is known as the CIL. These cold waters are sandwiched between warm solar-heated upper layer waters and the relatively warm, salty deep waters in the Laurentian Channel that originate from the slope water region off the continental shelf. Although the deeper waters are warmer than the CIL, their density is higher because of higher salinities. In winter, the CIL merges with the upper layer as the latter cools. The primary origin of the waters in the CIL is from atmospheric cooling of the water within the GSL in winter with an advection of cold Labrador Shelf water through the Strait of Belle Isle. The latter varies annually, but with a mean of approximately 15% of the total volume of the CIL (Galbraith 2006). The waters advected through the Strait of Belle Isle are saltier than winter waters found over the Magdalen Shallows, which are locally formed.

The average bottom water temperature field between 1971 and 2010 in September is shown in Figure 21. Bottom water temperatures range from <1°C to >17°C and most of the bottom is covered by waters <3°C with the largest portion of the Magdalen Shallows (50-80 m) covered by waters <1°C. Bottom waters with temperature <1°C can also be seen in Chaleur Bay. There is also an area covered with sub-zero waters over the Magdalen Shallows. On average, the warmest near-bottom water temperatures in the sGSL are found in the Northumberland Strait where the analysis shows that they can reach >23°C in September.

The time series of average bottom temperature in each LFA were derived from the June and September surveys (Figures 22 and 23). For June, the warmest year was observed in 1995 for many LFAs. For the deeper areas (e.g. 23BC, 24, 26B), the time series patterns are different than for those of surface waters, demonstrating the effect of stratification typically observed in these areas. The warmest LFA is 25S while the coolest is LFA 24 due to a large portion of its areas extending within the CIL. Trends are not significant in June, but clear increases can be observed in September from the mid-1990's to the end of the time series in some LFAs. However, the trend is not significant when combining all the LFAs together (bottom right panel on Figure 23).

The mean annual bottom water temperature cycle is shown in Figure 24 for each LFA. The cycles were obtained from VEMCO temperature probes deployed close to the bottom. Typically, there are only a few sensors deployed in each area and there may not be enough of them to average out bathymetry variations in some LFAs but since there are typically deployed on the same sites each year, there analysis is sufficient to represent the inter-annual variability. Again, LFA 25S shows the highest temperature in summer because shallow waters are more exposed to direct warming from the surface. Also, based on current observations, models suggest that the Northumberland Strait is essentially an isolated system during the summer months, i.e., little exchange with, slightly colder, adjacent waters (Comeau et al. 2008). Maximum temperatures are typically reached in August and September.

The average degree-days accumulation at the bottom is shown in Figure 25. These were obtained from near shore VEMCO temperature recorder. It is why LFA 24 shows the second highest accumulation of all the LFAs, i.e., that daily bottom temperatures from the deepest portion (cooler) of the LFAs were not available for inclusion in the analysis as the VEMCO probes are typically deployed in water less that 15 m deep.

## BOTTOM WATER SALINITY

The 1991-2010 September average bottom salinity field is shown in Figure 26. All of the sGSL is covered with salinities <34 with the largest portion being comprised between 31 and 33. The freshest waters are observed along the coast of NB reflecting the influence of the freshwater discharge and circulation within the GSL.

## BOTTOM WATER TEMPERATURES OCCUPIED BY LOBSTER

The historical lobster concentrations were derived from sale slips information and the 1968-2010 average lobster concentration estimates are shown in Figure 27. Frequency distribution of lobster concentrations and bottom water temperatures estimated from the June and September surveys are presented in Figures 28 and 29. In June, 95% of the lobsters are found in bottom water temperatures between 0.1 and 13.3°C. In September, bottom water temperatures between 2.5 and 18.2 °C covered the lobster distribution.

Based on the bottom water temperatures occupied by lobster, the time series of the surface area available to the species were then calculated for the entire sGSL for June (Figure 30) and September (Figure 31). Although there is a lot of inter-annual variability, the temperature habitat potentially suitable for lobster has been clearly increasing in June during the 1999-2012 time period. In September, the habitat index has also been increasing during the same period but to a lesser extent and with a decreased internal variability compared to the 1985-1995 period.

## SUMMARY

Basic environmental condition information relevant to lobster in the sGSL was presented. The results show that recent annual mean air temperatures have been above normal, with 2010 having the highest temperature on record surpassing 1999, 2006 and 2012. Furthermore, maximum ice volumes of years 2010 to 2012 were among the lowest values since 1969. Accordingly, the volume of the CIL also shows a decrease in recent years. SST in LFAs have been generally increasing between 1986 and 1999 and relatively stable since. The ocean surface degree-days accumulation over 4°C was variable but the rate was the fastest in 2006 and the slowest in 2011 over all the LFAs. Small increases in bottom water temperatures were observed since the mid1990's in several LFAs. Frequency distribution calculations show that 95% of the lobsters are found in bottom water temperatures between 0.1 and 13.3°C in June while they are found in temperatures between 2.5 and 18.2 °C in September. Based on bottom water temperatures, the surface area available to lobsters shows significant variability and has been increasing in June between 1999 and 2012. In September, an increase has also occurred during the same period but to a lesser extent.



## ACKNOWLEDGEMENTS

We thank L.Savoie, T. Hurlbut and J. Spry for providing the CTD data from the multi-species surveys and M. Moriyasu, M. Biron, E. Wade, P. DeGrâce and J.F. Landry for the temperature data from the snow crab surveys. We thank D. Gagnon, G. Paulin and D. Giard for providing the VEMCO temperature data. Also, special thanks go out to the scientists, technicians and crew who collected these data and did the quality control.


## REFERENCES


Comeau, M., Hanson, J.M., Rondeau, A., Mallet, A., and Chassé, J. 2008. Framework and Assessment for American Lobster, *Homarus americanus*, Fisheries in the Southern Gulf of St. Lawrence: LFA 23, 24, 25, 26A and 26B. DFO. Can. Sci. Advis. Sec. Res. Doc. 2008/054, 115 p.

DFO. 2013. American lobster, *Homarus americanus*, stock status in the southern Gulf of St. Lawrence: LFA 23, 24, 25, 26a and 26b. DFO. Can. Sci. Advis. Sec. Sci. Advis. Rep. 2013/029.

Drinkwater, K.F, Pettipas, R.G., Bugden, G.L., and Langille, P. 1999. Climatic data for the Northwest Atlantic : a sea ice database for the Gulf of St. Lawrence and the Scotian Shelf. *Can. Tech. Rep. Hydrogr. Ocean Sci.* 199: iv + 134 p.

Galbraith, P.S. 2006. Winter water masses in the Gulf of St. Lawrence. J. Geophys. Res. 111: C06022, doi:10.1029/2005JC003159.

Galbraith P.S., Larouche, P., Chassé, J., and Petrie, B. 2012. Sea-surface temperature in relation to air temperature in the Gulf of St. Lawrence: interdecadal variability and long term trends. Deep Sea Res. II V77–80, 10–20.

Galbraith, P.S., Chassé, J., Larouche, P., Gilbert, D., Brickman, D., Pettigrew, B., Devine, L., and Lafleur, C. 2013. Physical Oceanographic Conditions in the Gulf of St. Lawrence in 2012. DFO. Can. Sci. Advis. Sec. Res. Doc. 2013/026. v + 89 p.

Lawton, P., and Lavalli, K.L. 1995. Postlarval, juvenile adolescent, and adult ecology. In: Biology of the Lobster *Homarus americanus* (ed. J.R. Factor) Academic Press, San Diego: 47-88.

# FIGURES

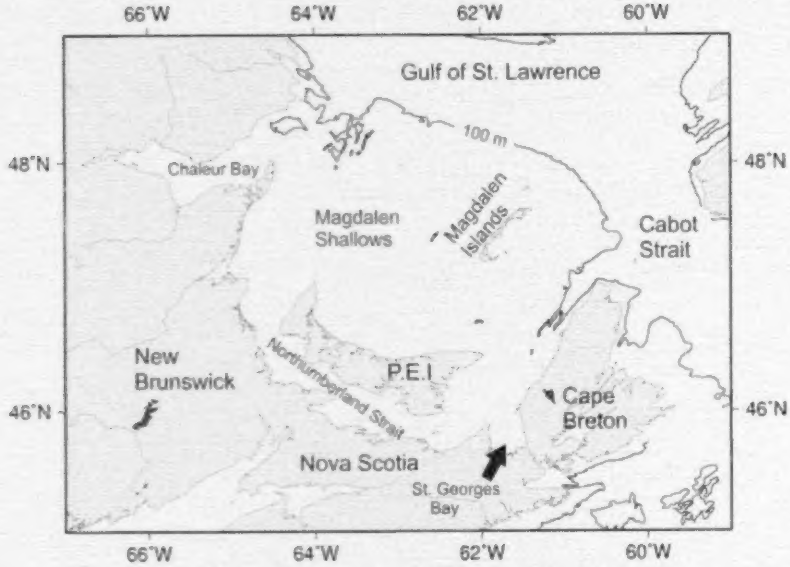


*Figure 1. Chart of the southern Gulf of St. Lawrence showing geographic and topographic features referred to in the text.*

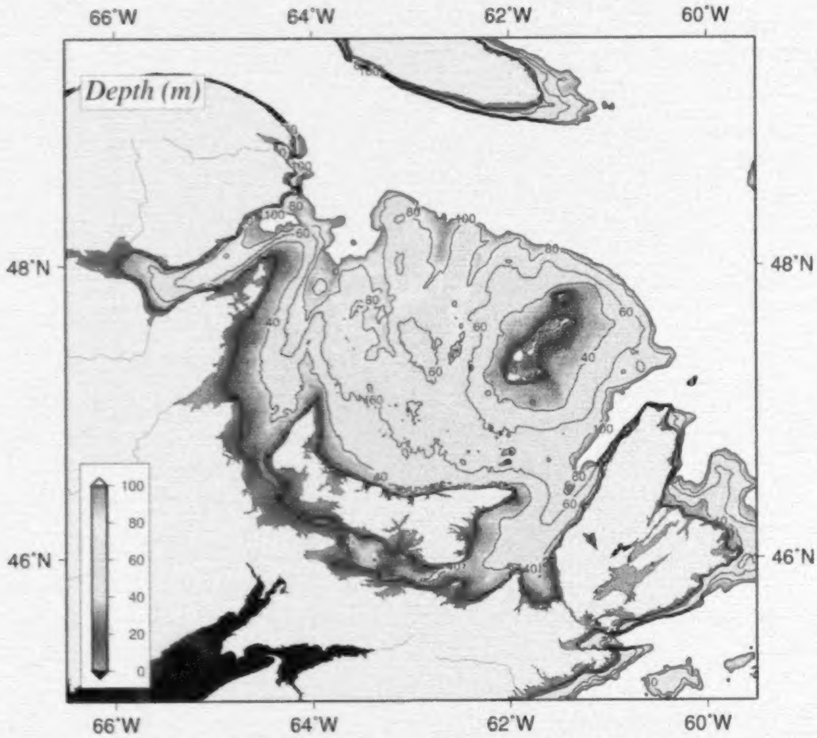


*Figure 2. Bathymetry (m) of the Southern Gulf of St. Lawrence.*

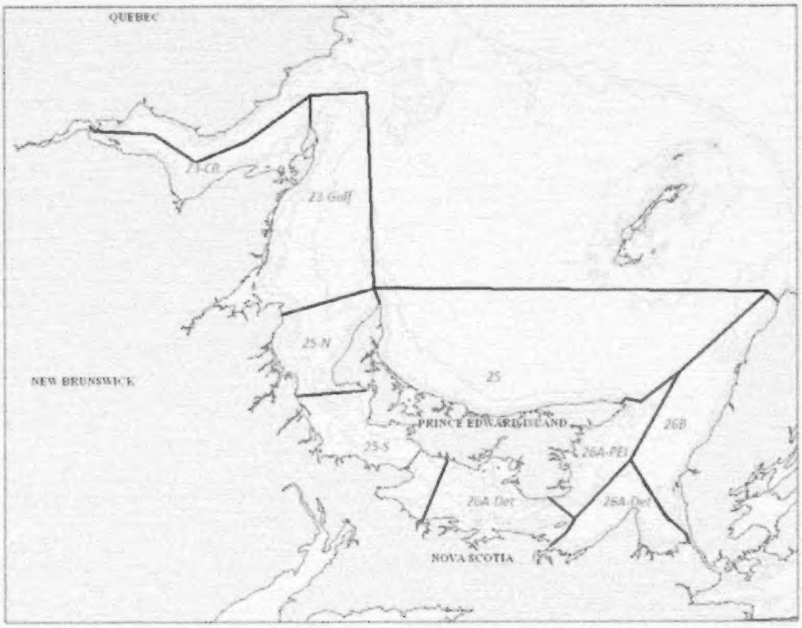


*Figure 3. The southern Gulf of St. Lawrence showing by black lines the boundaries of the lobster fishing areas.*

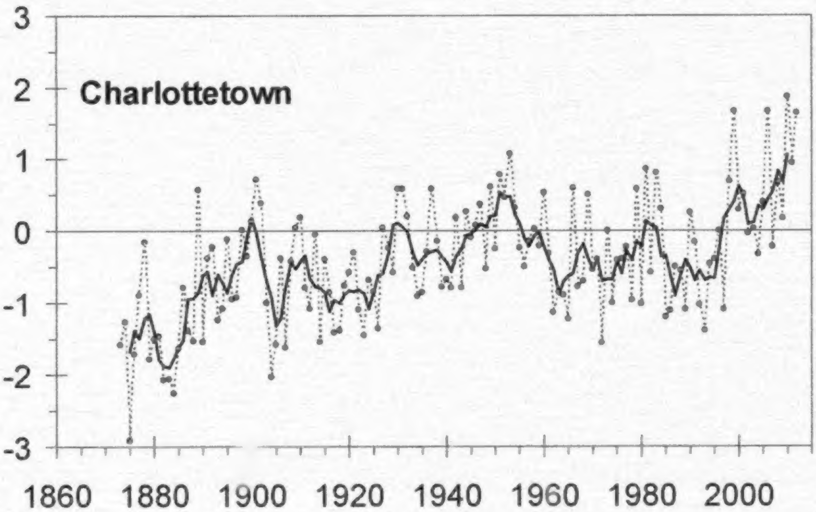


*Figure 4. Time series of the air temperature anomaly at Charlottetown. The anomaly was calculated relative to the 1981-2010 average.*

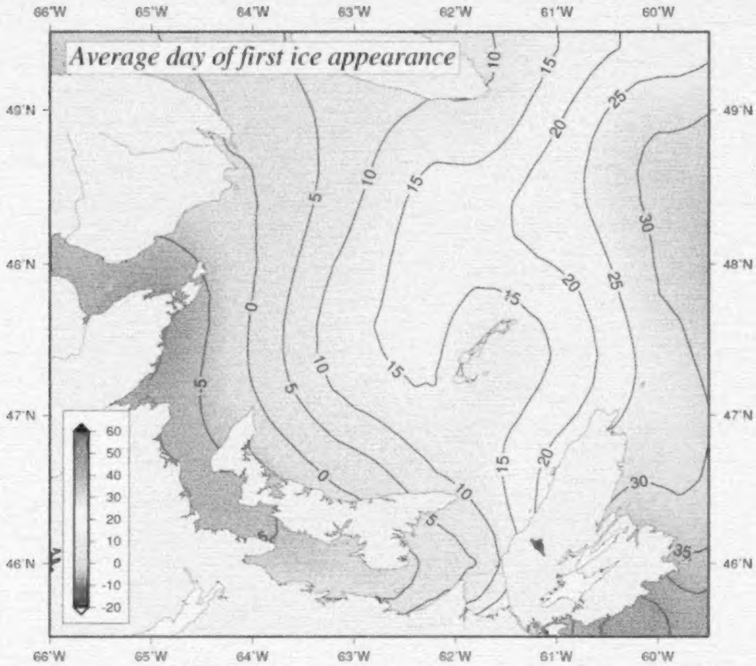


*Figure 5. Average day of the year of the first ice appearance (1971-2000 climatology).*

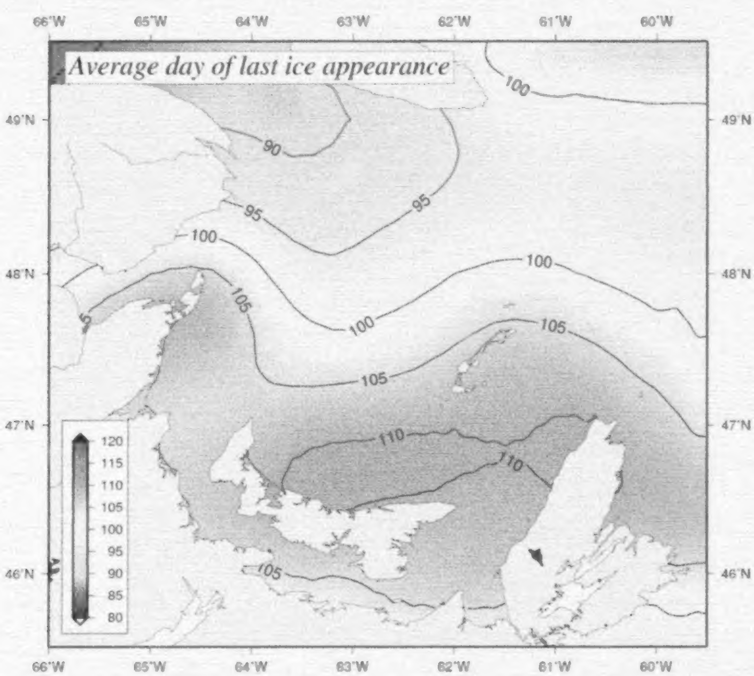


*Figure 6. Average day of the year of the last ice appearance (1971-2000 climatology).*

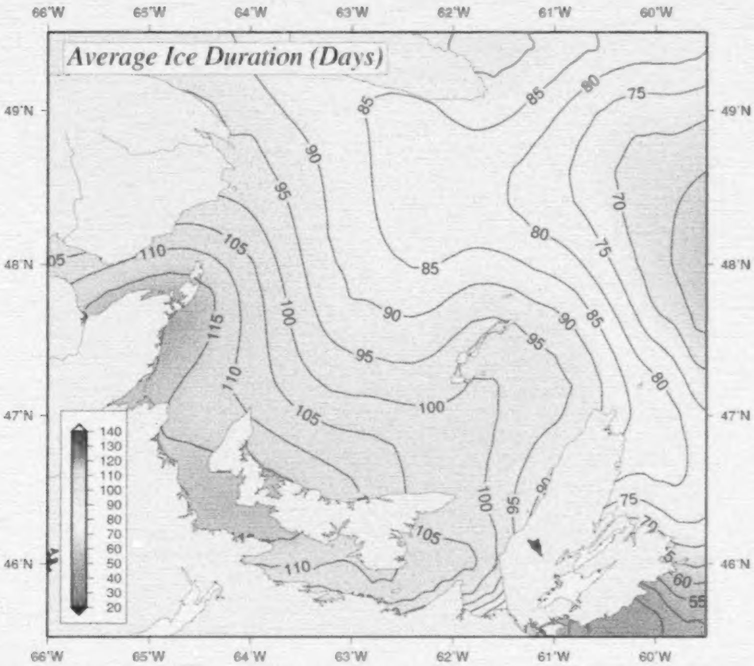


*Figure 7. Average ice duration in days (1971-2000 climatology).*

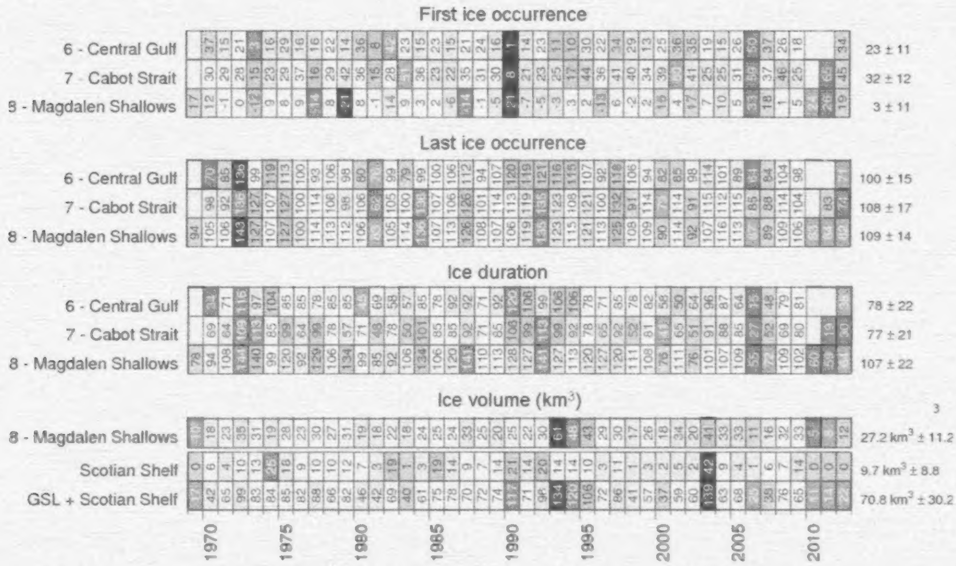


*Figure 8. First and last day of the year of ice occurrence, ice duration, and maximum seasonal ice volume for three regions. The time when ice was first and last seen in days from the beginning of each year is indicated for each region, and the colour code expresses the anomaly based on the 1981–2010 climatology, with blue representing earlier first occurrence and later last occurrence (modified from Galbraith et al. 2012).*

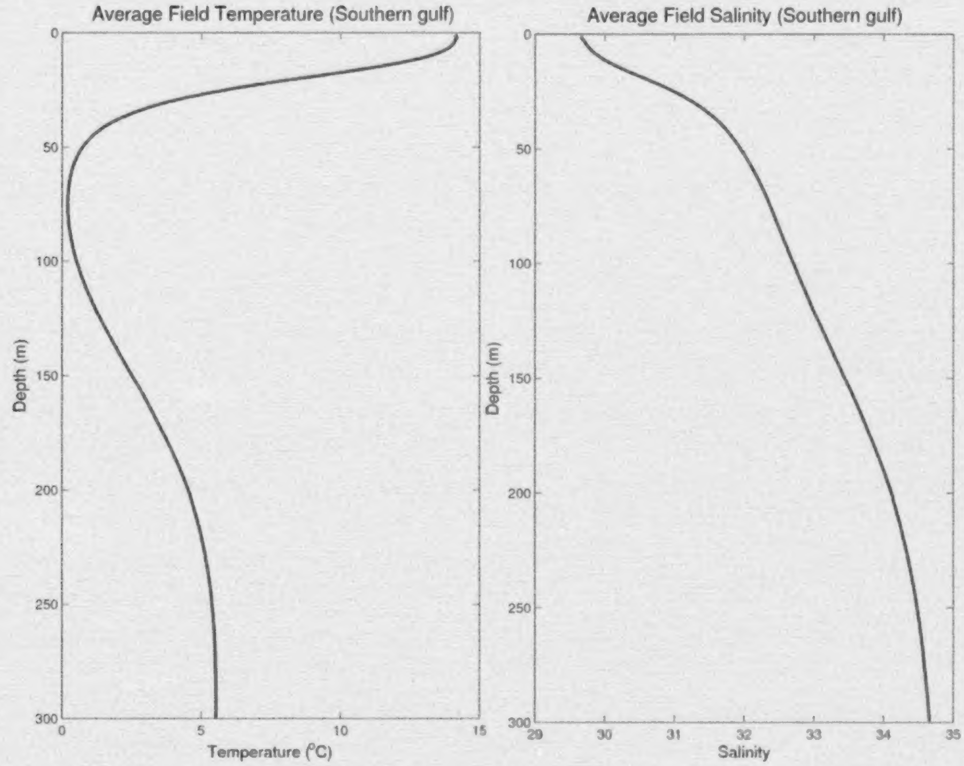


*Figure 9. Average temperature (left) and salinity (right) profiles between 1971 and 2010 for September in the southern Gulf of St. Lawrence.*

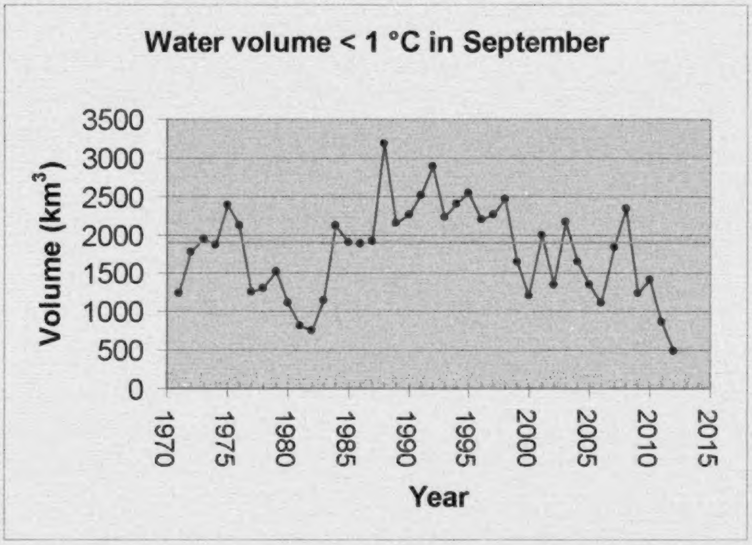


*Figure 10. Cold Intermediate Layer volume (T < 1°C) over the southern Gulf of St. Lawrence for September from 1971 to 2012.*

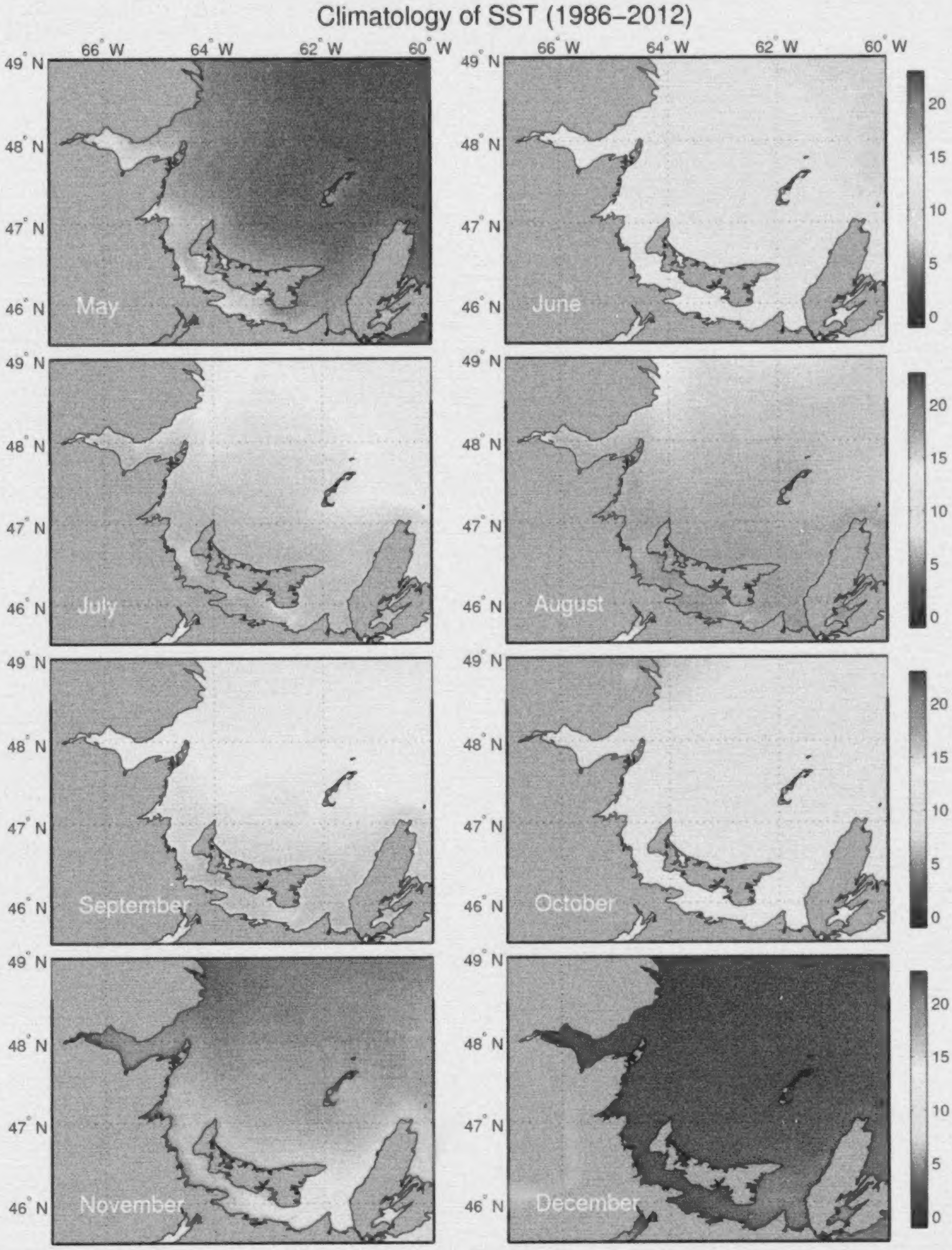


*Figure 11. Sea Surface Temperature (SST) climatology (1986-2012) from May to December obtained from Institut Maurice-Lamontagne remote sensing laboratory.*

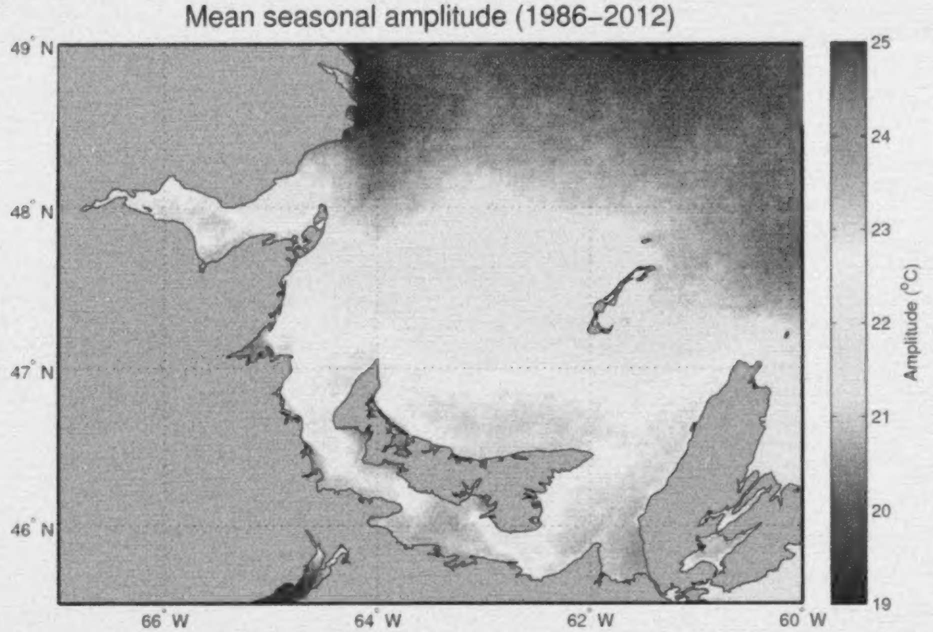


*Figure 12. Average (1986-2012) seasonal amplitude of the sea surface temperature cycle.*

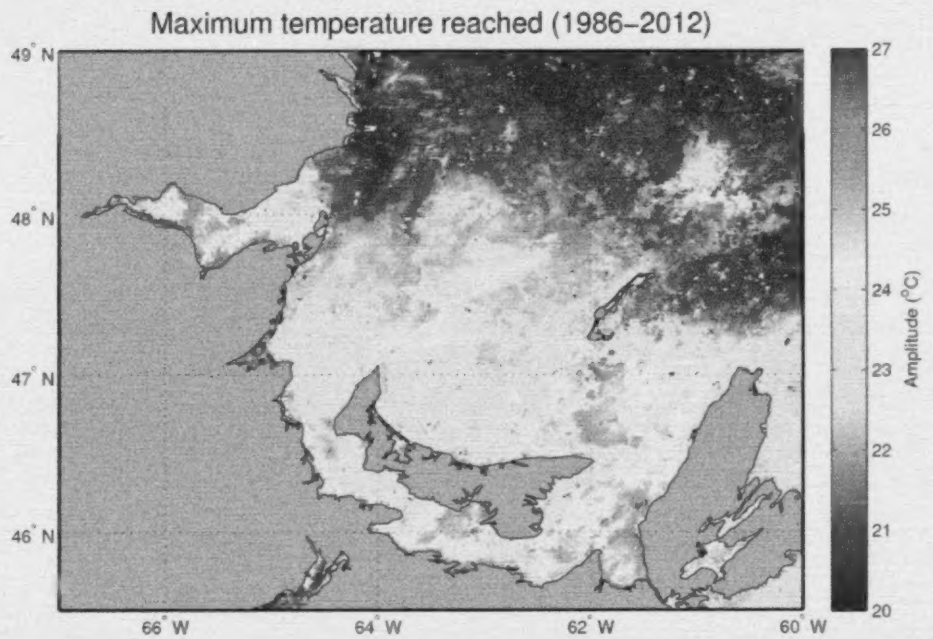


*Figure 13. Highest Sea Surface Temperature recorded from 1986 to 2012 in the southern Gulf of St. Lawrence.*

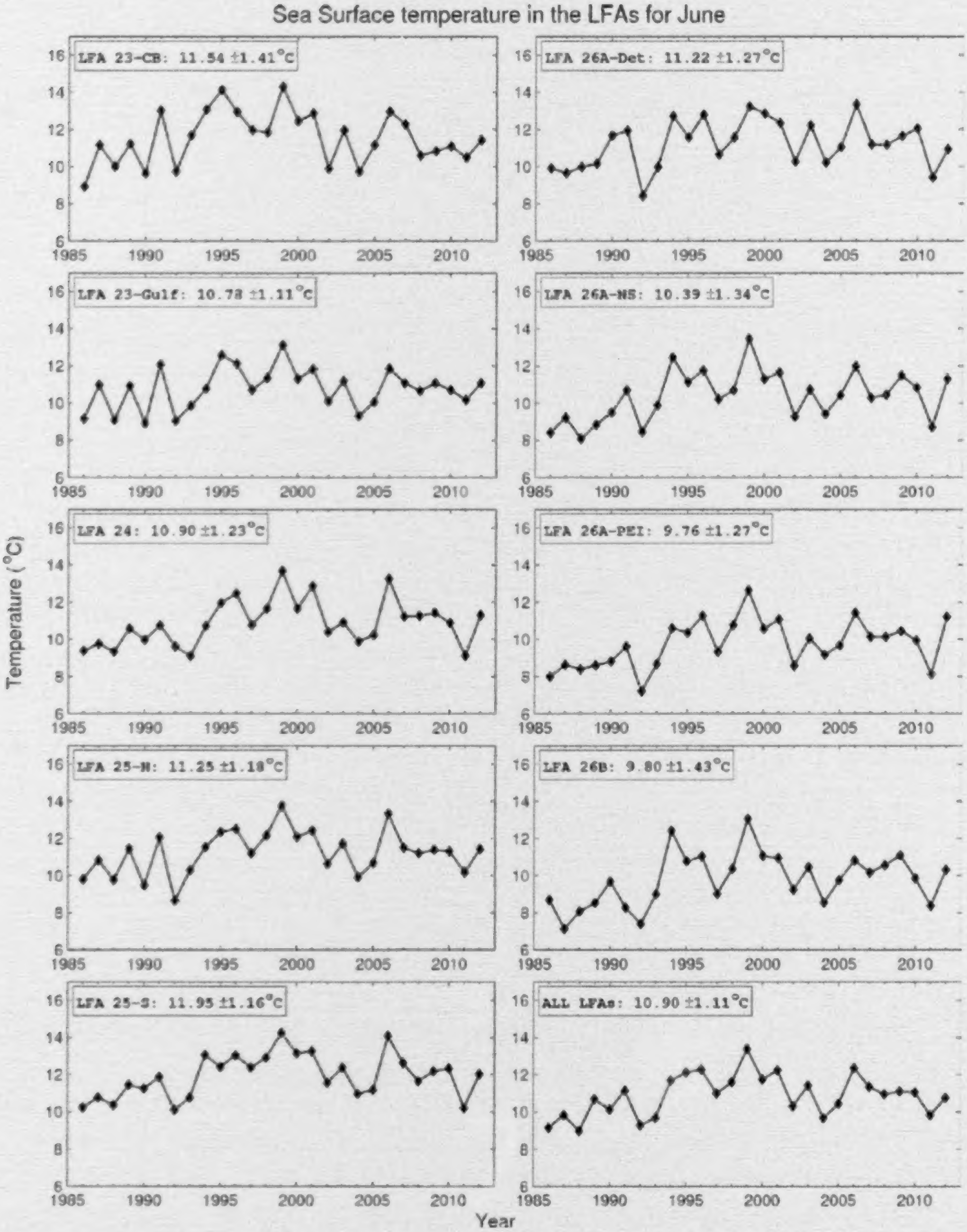


*Figure 14. Time series of Sea Surface Temperature in June for each Lobster Fishing Area (LFA).*

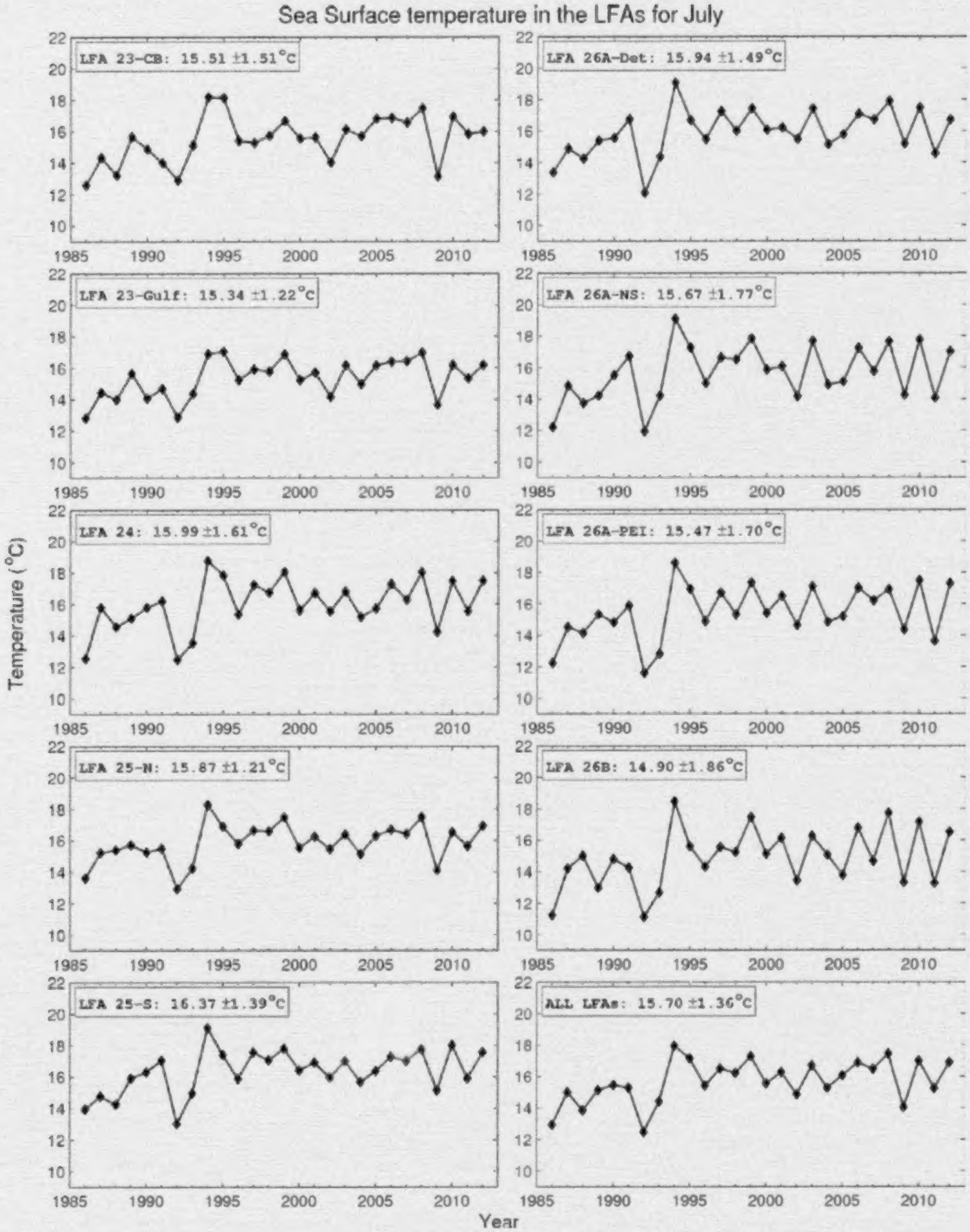


*Figure 15. Time series of Sea Surface Temperature in July for each Lobster Fishing Area (LFA).*

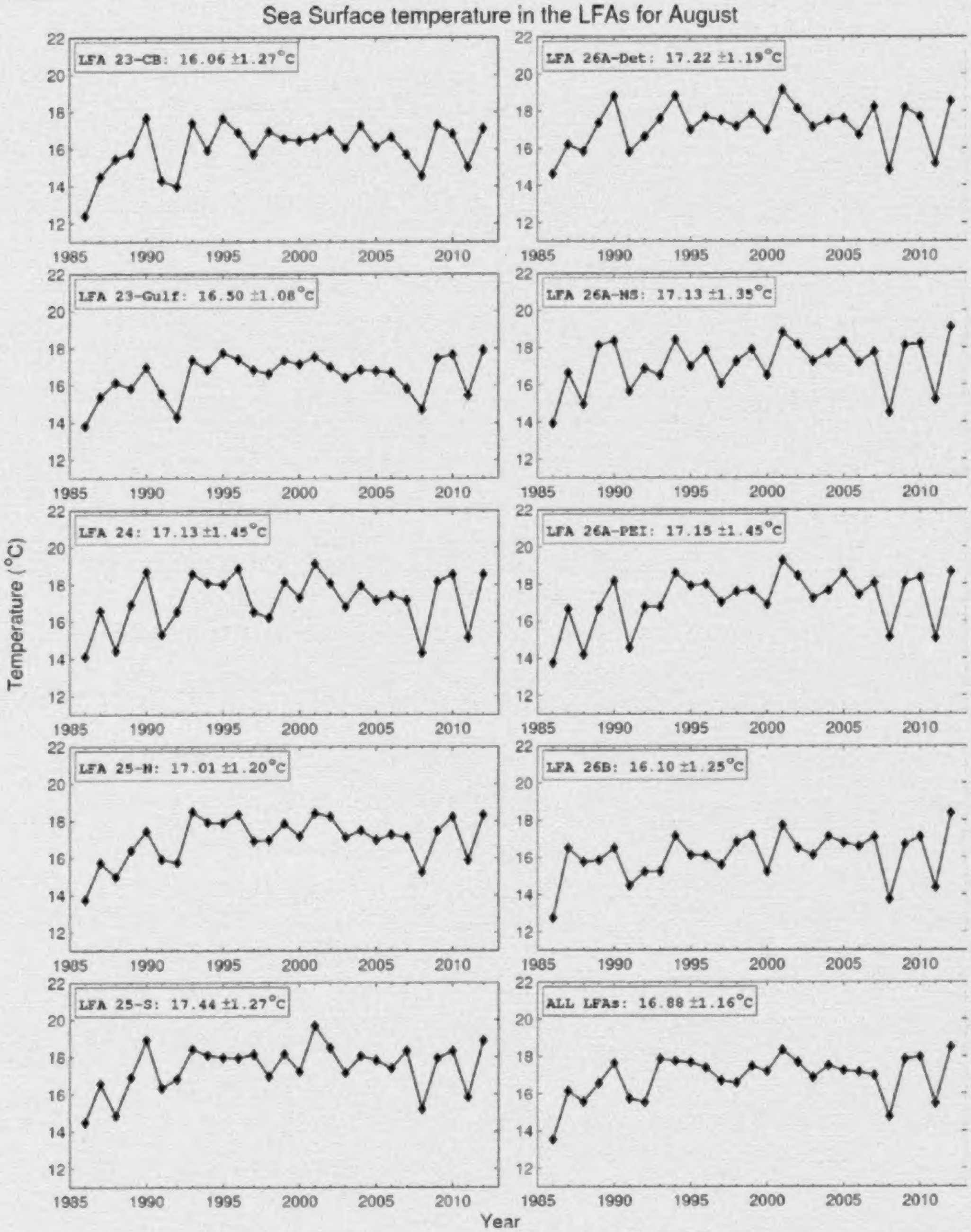


*Figure 16. Time series of Sea Surface Temperature in August for each Lobster Fishing Area (LFA).*

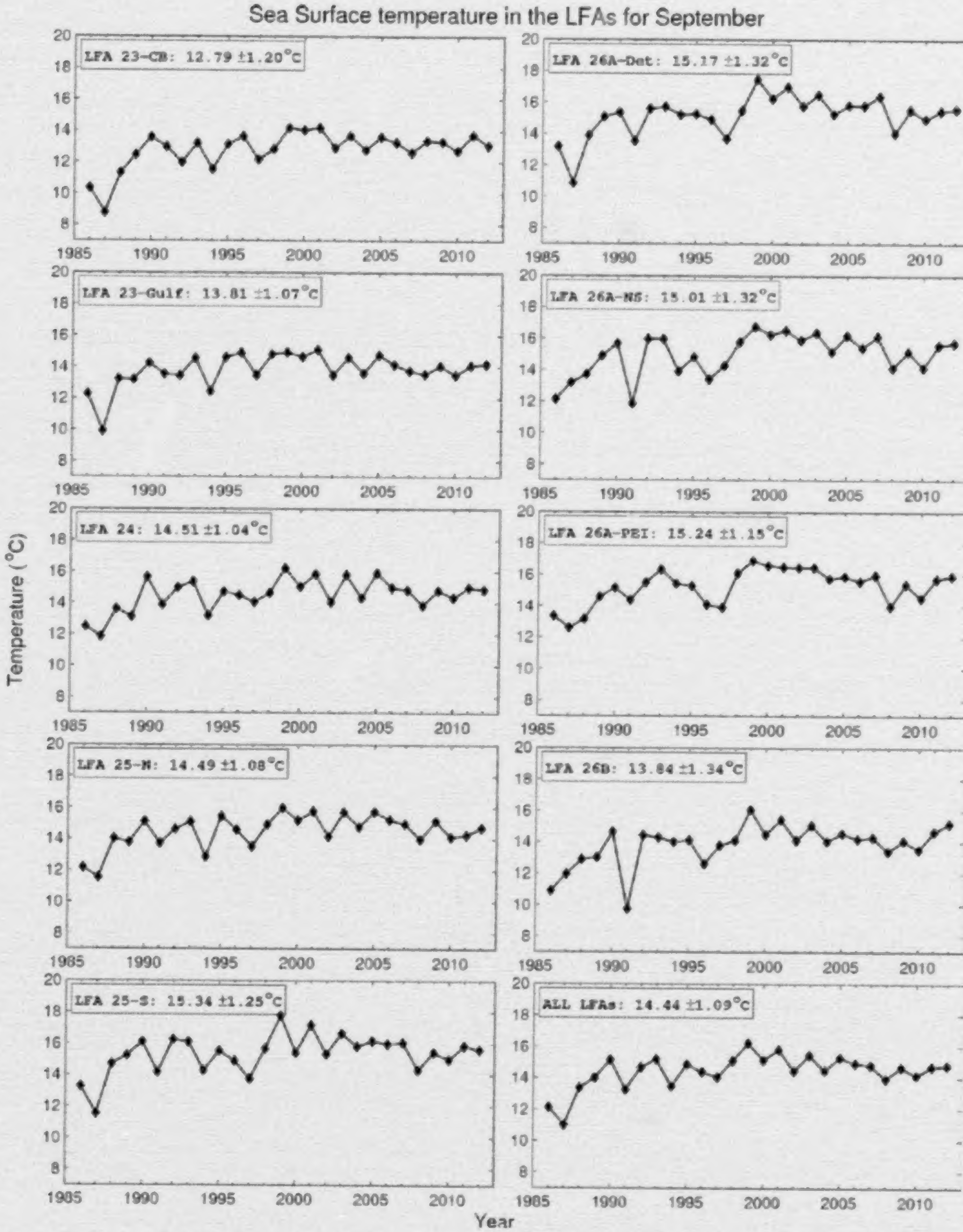


*Figure 17. Time series of Sea Surface Temperature in September for each Lobster Fishing Area (LFA).*

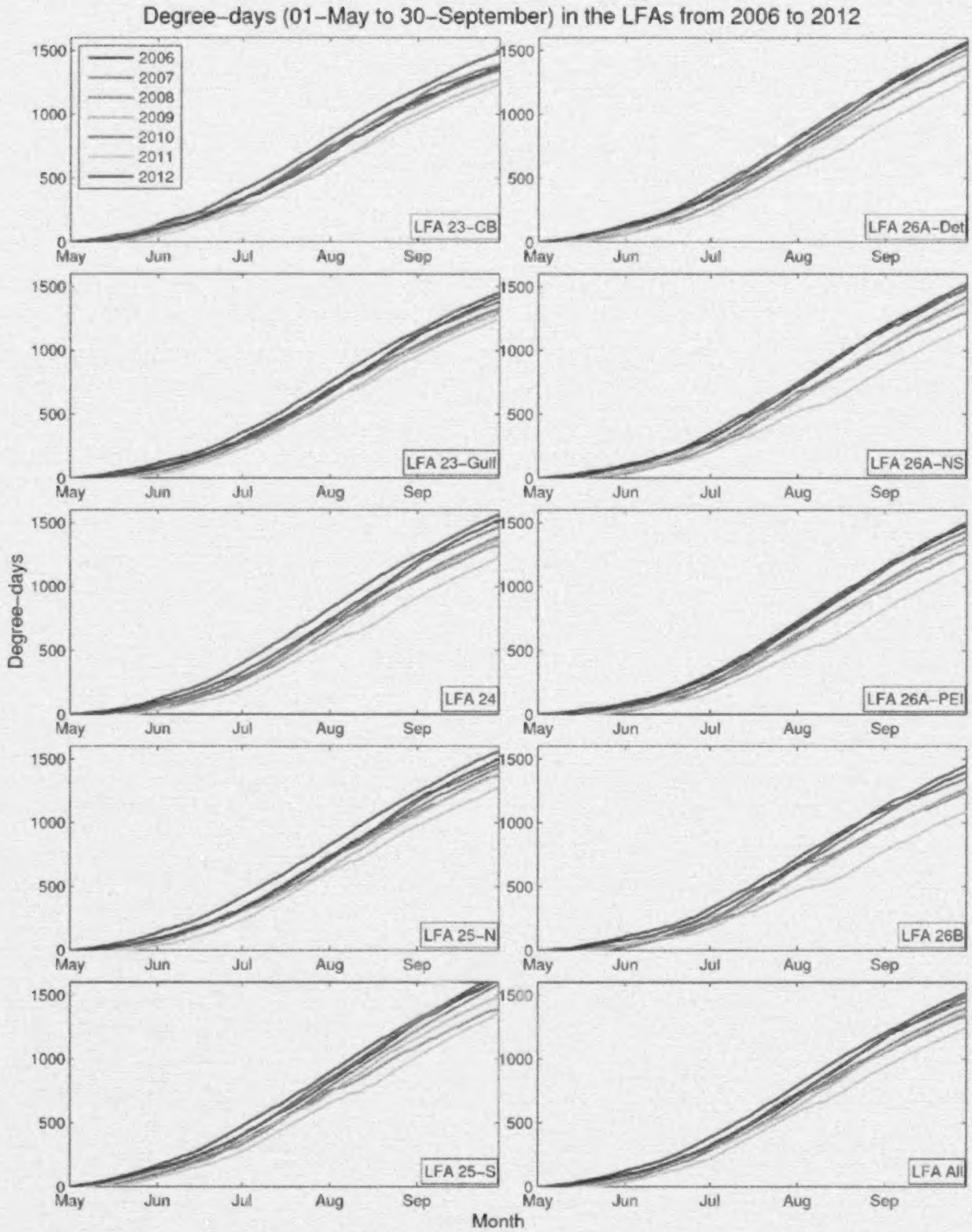


*Figure 18. Degree-days accumulation over 4°C at the surface for each Lobster Fishing Area (LFA) between 2006 and 2012.*

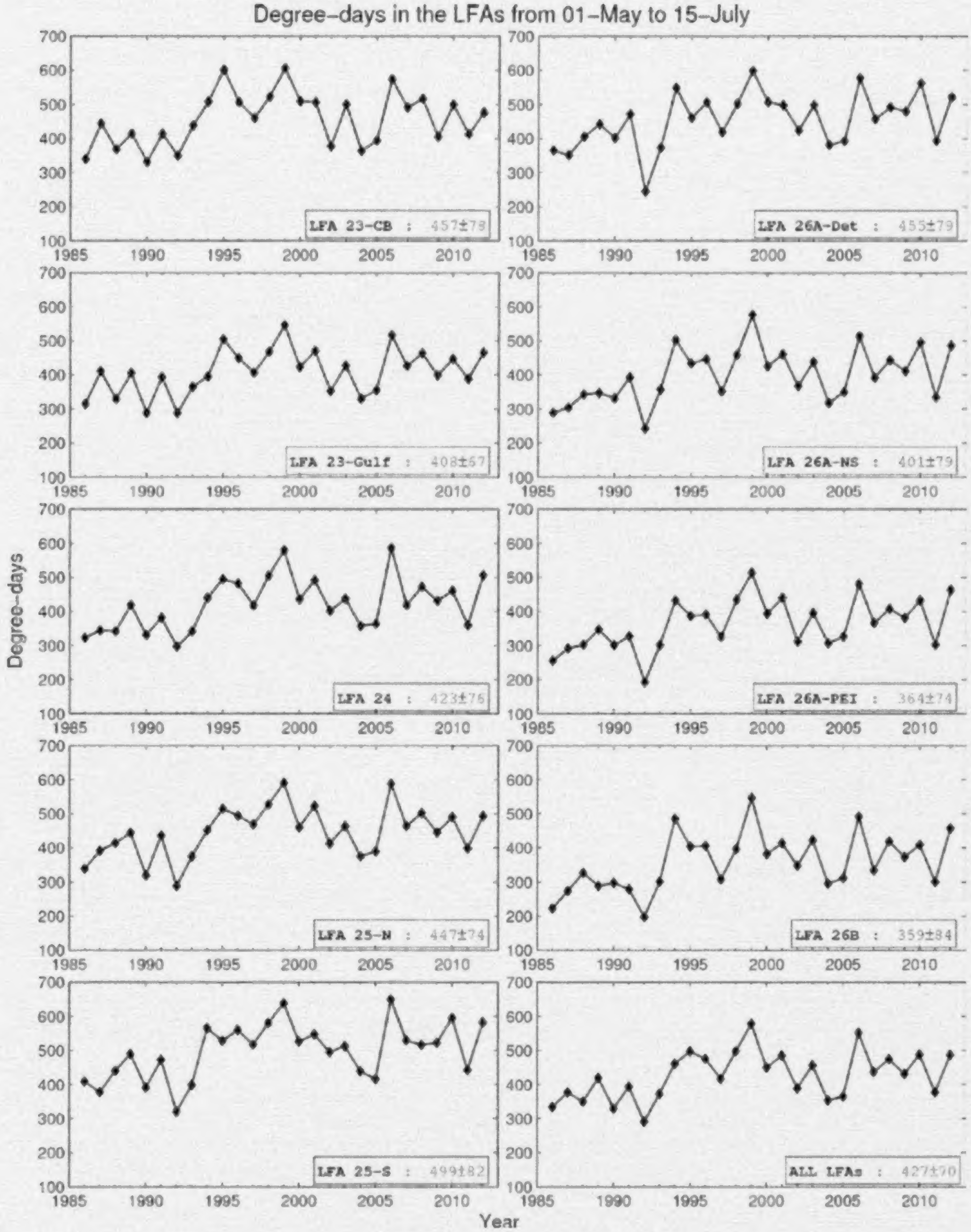


*Figure 19. Time series of degree-days accumulation over 4°C at the surface between May 1st and July 15th for each Lobster Fishing Area (LFA) from 1985 to 2012.*

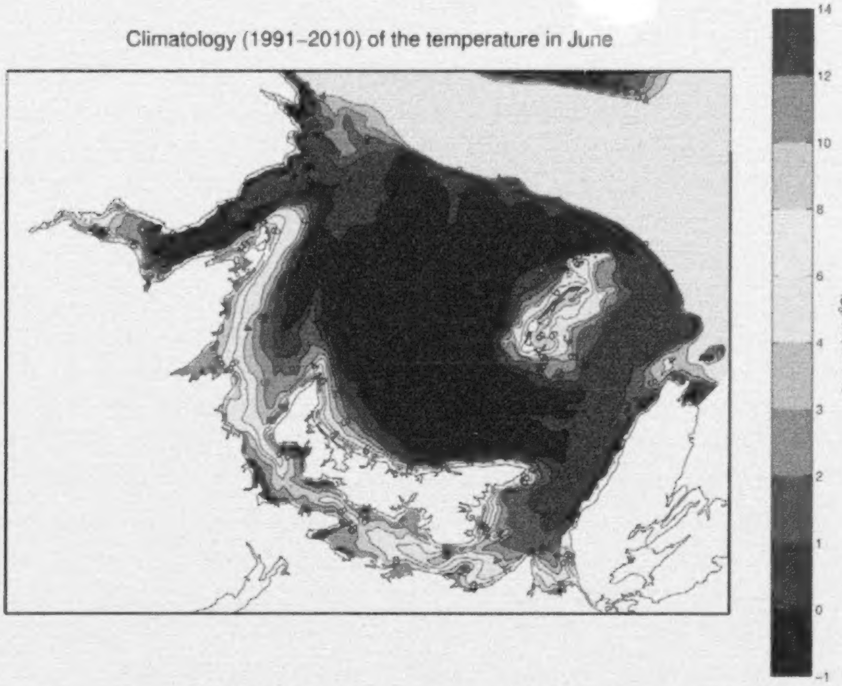


*Figure 20. Average bottom water temperatures (°C) between 1991 and 2010 in June for the southern Gulf of St. Lawrence.*

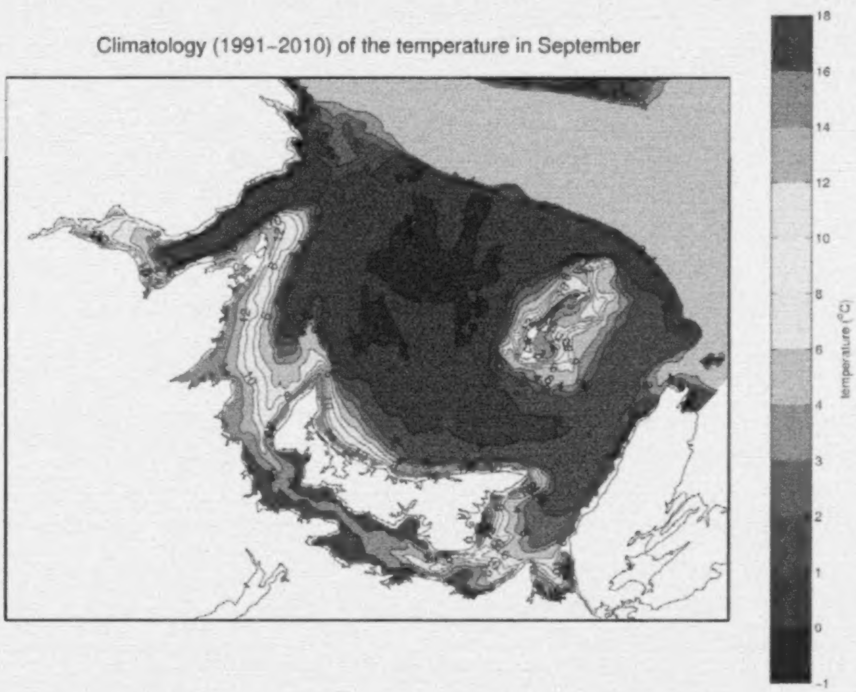


*Figure 21. Average bottom water temperatures (°C) between 1991 and 2010 in September for the southern Gulf of St. Lawrence.*

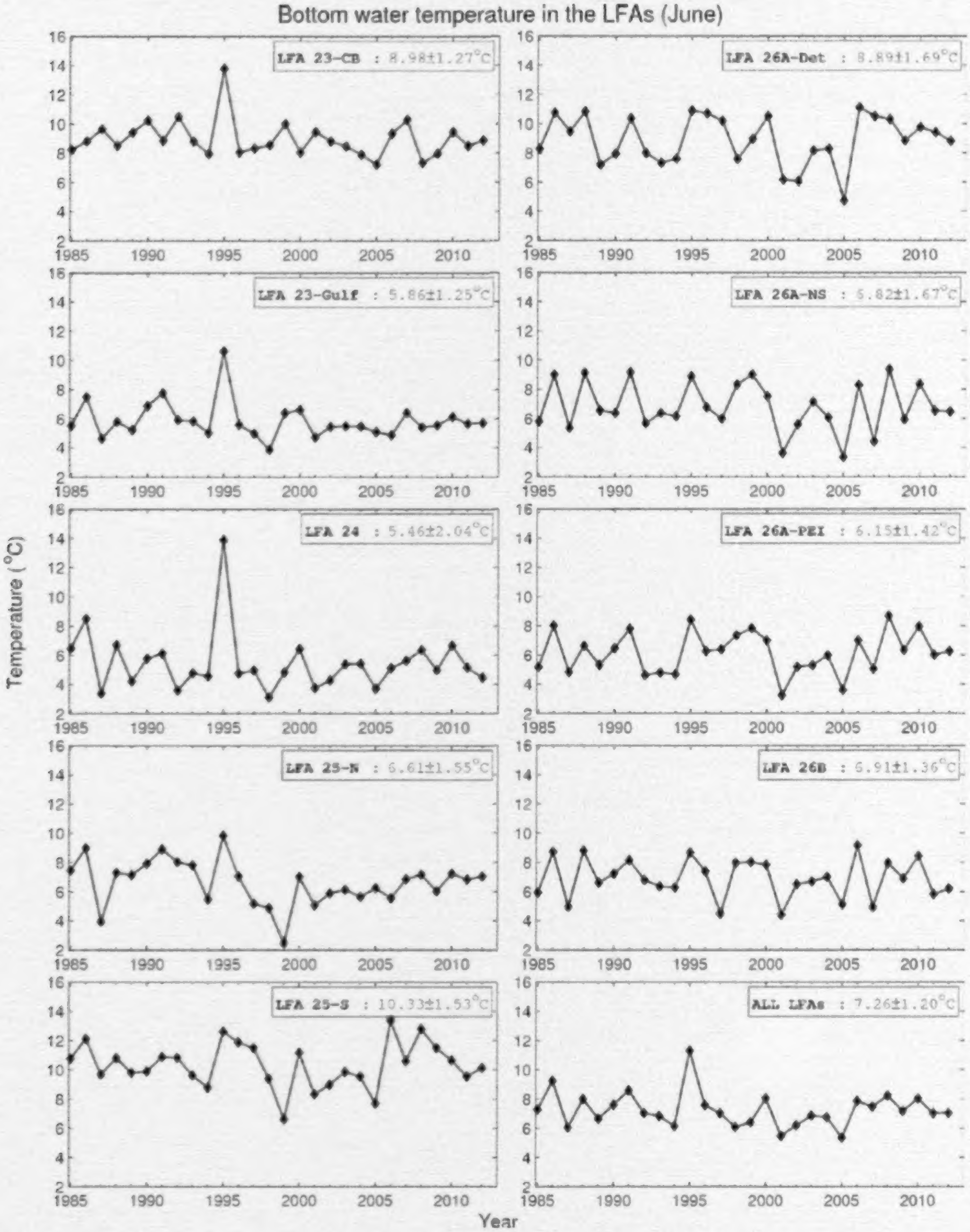


*Figure 22. Bottom water temperature time series for each Lobster Fishing Area (LFA) from the June survey.*

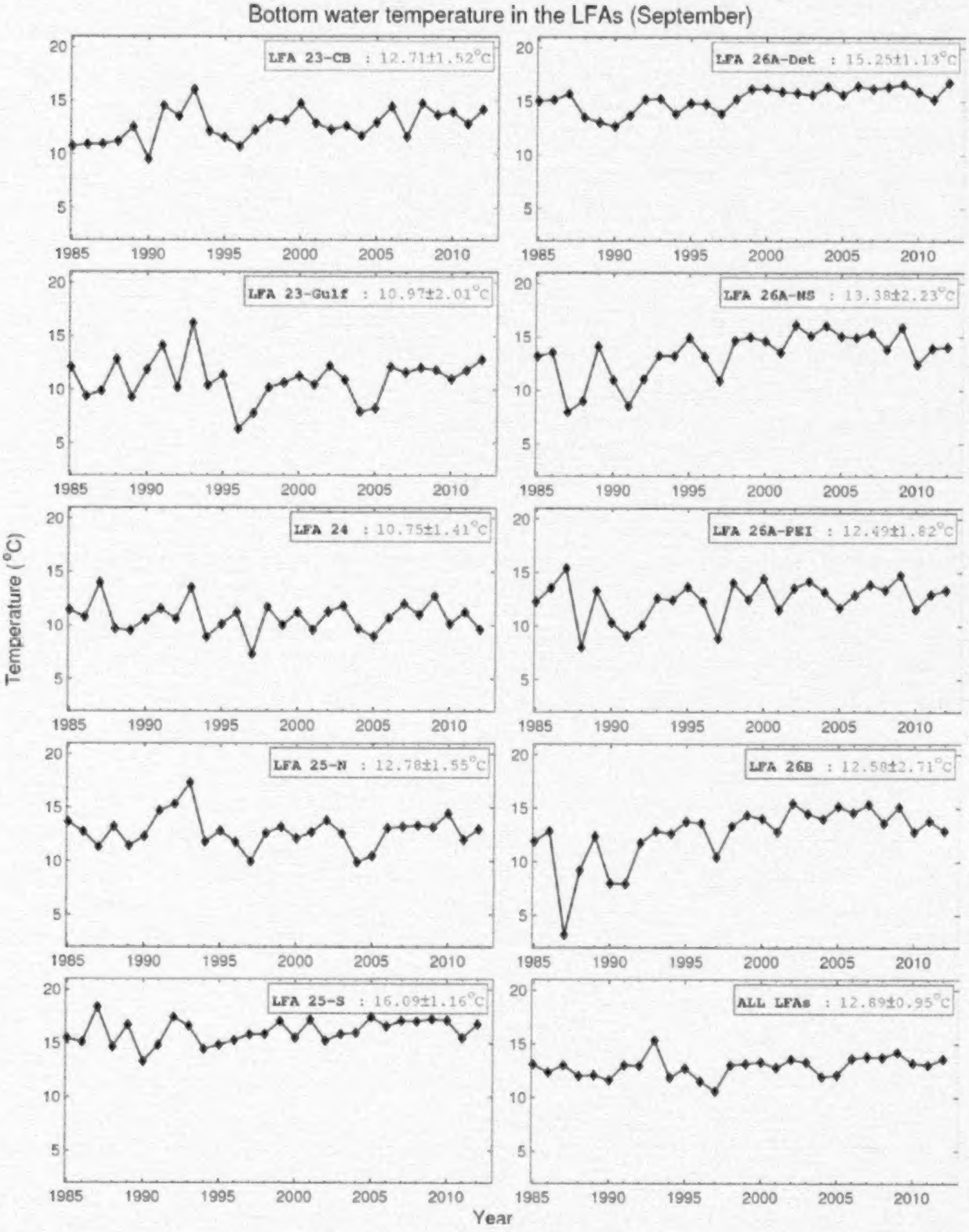


*Figure 23. Bottom water temperature time series for each Lobster Fishing Area (LFA) from the September survey.*

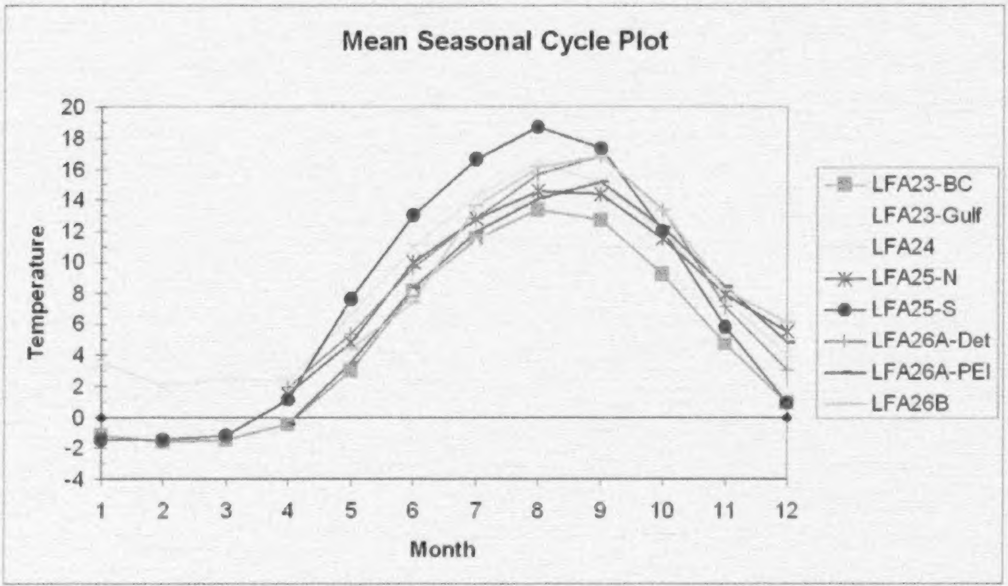


*Figure 24. Mean (1997-2004) seasonal bottom water temperature (°C) based on bottom VEMCO thermographs for each Lobster Fishing Area (LFA).*

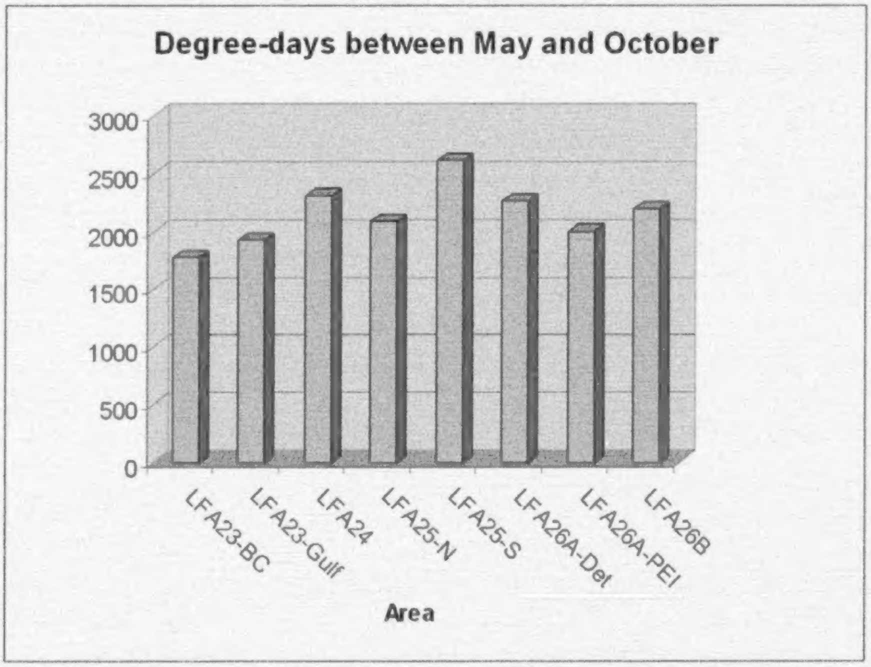


*Figure 25. Average (1997-2004) degree-days at the bottom between May 1st and September 31st.*

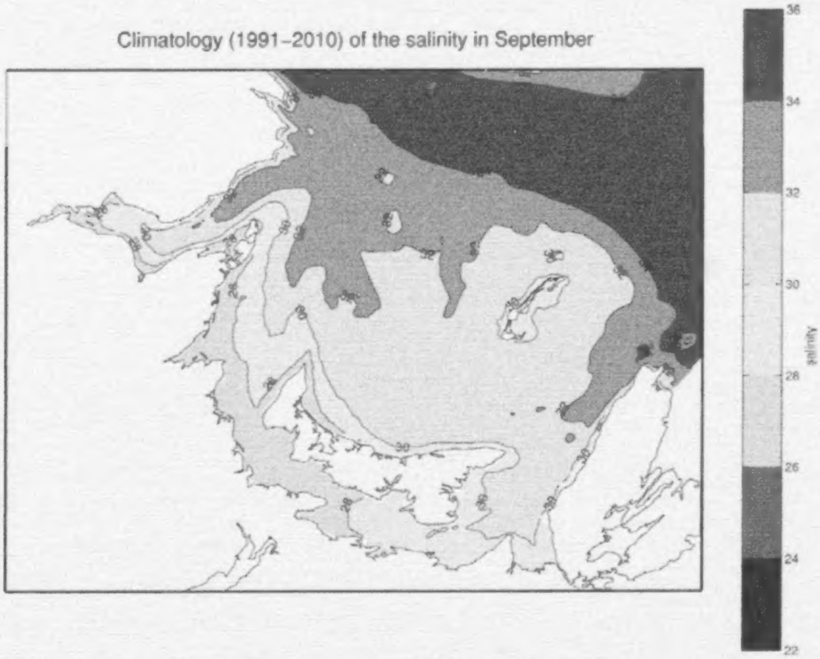


*Figure 26. Average bottom water salinity (psu) in September between 1991 and 2010 for the southern Gulf of St. Lawrence.*

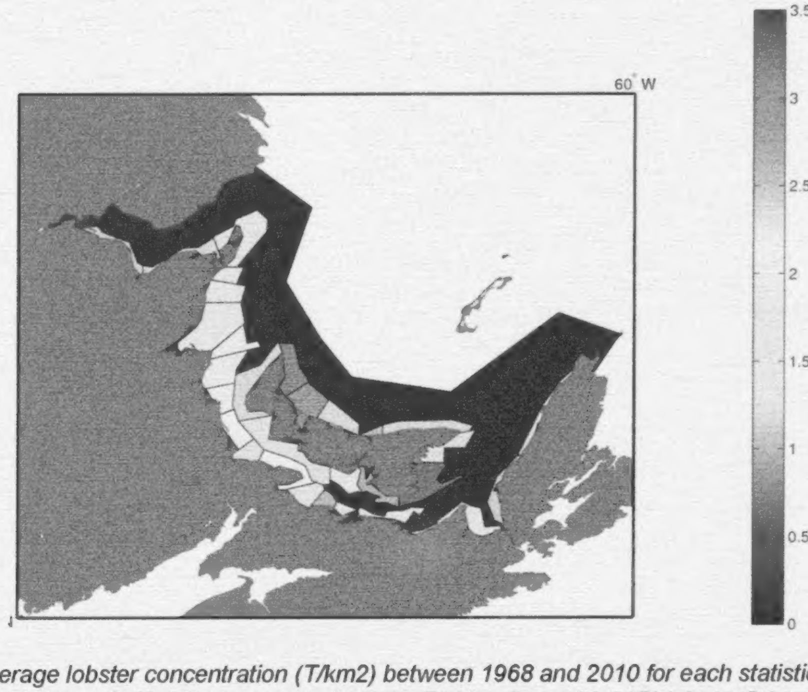


*Figure 27. Average lobster concentration (T/km2) between 1968 and 2010 for each statistical district located in the southern Gulf of St. Lawrence (Lobster Fishing Areas 23-26B) lobster fishery. The lobster concentration is based on commercial landings obtained from DFO Statistical Branch in the Gulf Fisheries Centre (Moncton, NB).*

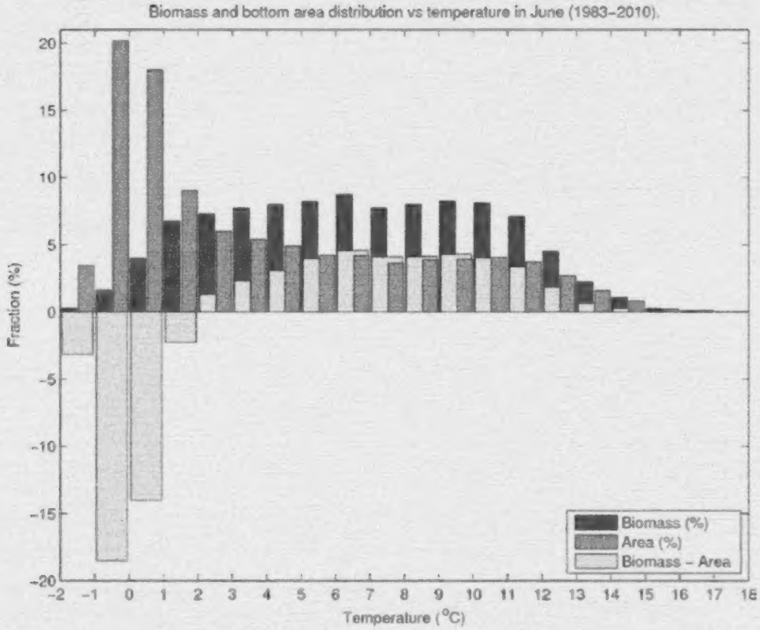


*Figure 28. Bottom area and lobster biomass frequency distributions as a function of bottom water temperature in June for the 1983-2010 period. The green bars represent their difference.*

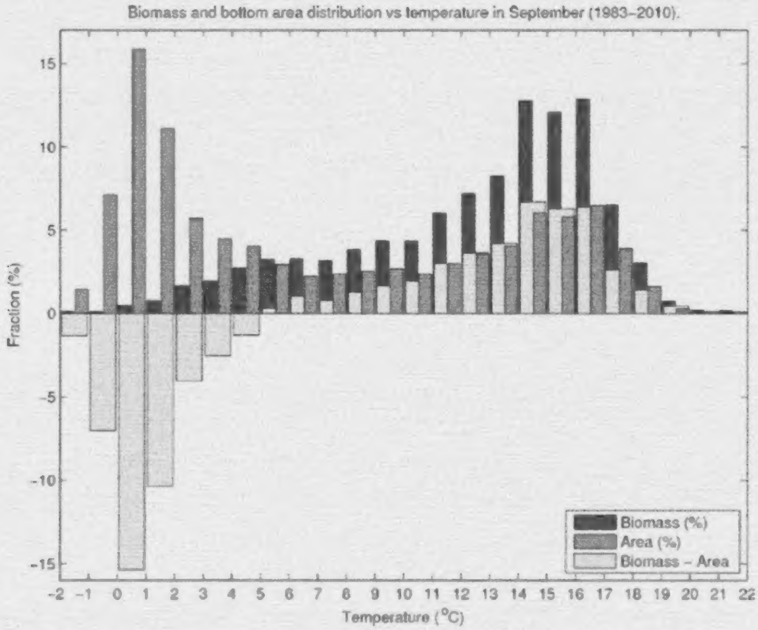


*Figure 29. Bottom area and lobster biomass frequency distributions as a function of bottom water temperature in September for the 1983-2010 period. The green bars represent their difference.*

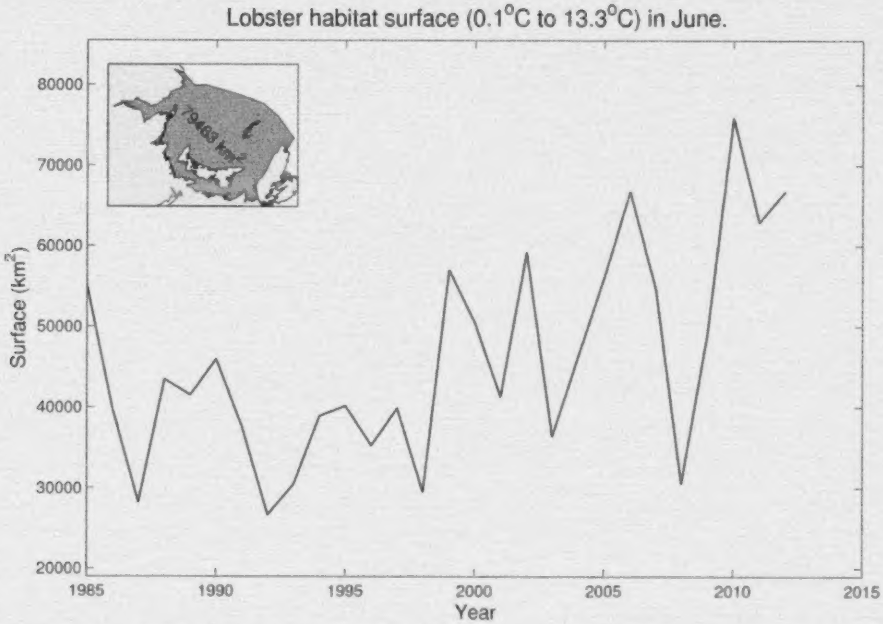


*Figure 30. Time series of June lobster preferred habitat surface in the southern Gulf of St. Lawrence. The domain used for the statistics is represented in red.*

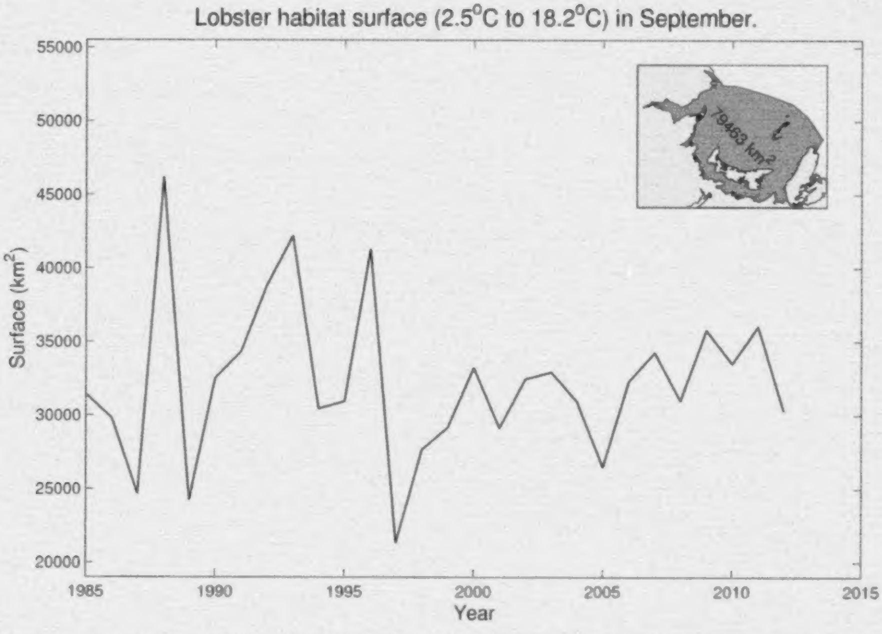


*Figure 31. Time series of September lobster preferred habitat surface in the southern Gulf of St. Lawrence. The domain used for the statistics is represented in red.*